Faculty of Engineering

MECHANICAL PROPERTIES OF BEMBAN FIBRES COMPOSITES

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This project report attached here to, entitled **"Mechanical Properties of Bemban Fibres Composites"** prepared and submitted by **Norhayati binti Yahaya** as a partial fulfillment of the requirement for the degree in Bachelor of Engineering with Honors in Mechanical Engineering and Manufacturing System is hereby read and approved by:

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ABSTRACT

Bemban (*Donax Grandis*) bast fibre, natural fibre was combined with polyester resin matrix to produce fibre composites. The composites were fabricated using continuous reinforcing fibres, 0 and 90-degree properties. These are to evaluate the effect of lay-up sequence on the mechanical properties of the composites. A tensile test has been carried out and all the specimens were conditioned according to ASTM D3039 before carry out the test. This research and experimental work are done in order to evaluate the potential of natural fibre that can be found in Sarawak, which are bemban.

ABSTRAK

Fiber daripada tumbuhan Bemban (*Donax Grandis)* dicampurkan dengan ‘polyester resin’ untuk menghasilkan fiber komposit. Komposit ini menggunakan fiber yang berterusan serta berorientasikan 0, 90, dan 0/90 darjah. Ini bertujuan untuk mengkaji kesan ‘lay-up sequence’ terhadap ciri-ciri mekanikal komposit. Ujian ‘tensile’ dilakukan ke atas spesimen dan keseluruhan spesimen ini disediakan dengan merujuk kepada “America Standard Test Method’ ASTM D3039. Kajian dan kerja-kerja eksperimen dijalankan ke atas fiber komposit bemban untuk melihat potensi fiber semulajadi yang terdapat di Sarawak, iaitu Bemban.

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CHAPTER 1

INTRODUCTION

1.1 Composite materials

The use of composite materials dates from centuries ago, and it all started with natural fibres. In ancient Egypt, some 3000 years ago, clay was reinforced by straw to build walls (W.D. (Rik) Brouwer, 2003). Bledzki and Gassan (1999) reported that natural fibers were used as early as 1908 in the fabrication of large quantities of sheets, where paper or cotton was used to reinforce sheets made of phenol- or melamine-formaldehyde resins. Later on, the natural fibres lost much of its interest.

During the sixties, the rise of composite materials began when glass fibres in combination with tough rigid resins was produced on large scale. The last decade, there is a renewed interest in the natural fibre as a substitute for glass. The reason for the interest in using natural fibres is due to the composite possesses better electrical resistance, good thermal and acoustic insulation properties and higher resistance to fraction. Fibres like flax, kenaf, hemp, jute or sisal, have better stiffness per unit weight, renewability, and biodegradability. Natural fibres are relatively low cost than synthetic fibre and could replace them in applications where cost consideration outweighs strength requirements.

The most common is jute, which is cheap, and has a reasonable strength and resistance to rot. Jute is mainly used for packaging (sacks and bales). Flax has strong and stiff fibres. The fibres can be spun to fine yarns for textile (linen) (W.D. (Rik) Brouwer, 2003).

On the other hand natural fibres have their shortcomings. They have lower durability and lower strength than glass fibre. However, recently develop fibre treatments have improved these properties considerably.

Among the natural fibres, bemban is one of the plants, which naturally consists of long natural fibres and commonly found in lowland forest in Sarawak. Bemban reed is plant belonging to the family *Marantaceae*, especially the species *Donax grandis.* The bemban reed grows on wet ground near streams or on more hilly terrain. It's tall and bamboo like stems with leafy branches at their ends and large oval leaves are quite distinctive. The stems are made into second quality baskets and matting, and are also used for sewing ataps. The Iban bemban is a handsome, light to deep green plant with broad shiny leaves growing to a height of several metres (www.sarawakhandicraft.com/bembanfiles/mid_2_htm).

They are two types of bemban that used in planting: bemban air and bemban batu. Bemban air or also known as bemban paya (water or marsh bemban) grows closer to water, is fragile and only used in mats. Bemban batu or bemban bukit (stone or hill bemban) is tougher and lives on higher ground. It is of a deeper green than the other varieties and is used for baskets. Table 1.1 shows the properties of glass fibres and some of the natural fibres. The picture of bemban reed plant is illustrated in Figure 1.1.

Table 1.1: Properties of glass and natural fibres (W.D. (Rik) Brouwer, 2003)

Properties	Fibre							
	E-glass	flax	hemp	jute	ramie	coir	sisal	Cotton
Density g/cm^3	2.55	1.4	1.48	1.46	1.5	1.25	1.33	1.51
Tensile strength* 10E^6 N/m^2	2400	800 - 1500	550 - 900	400 - 800	500	220	600-700	400
E-modulus (GPa)	73	60 - 80	70	10 - 30	44	6	38	12
Specific (E/density)	29	26 - 46	47	7 - 21	29	5	29	8
Elongation at failure (%)	3	1.2 - 1.6	1.6	1.8	2	15 - 25	2 - 3	3 - 10
Moisture absorption (%)	-	7	8	12	12 -17	10	11	8 - 25

*Tensile strength strongly depends on type of fibre, being a bundle or a single filament.

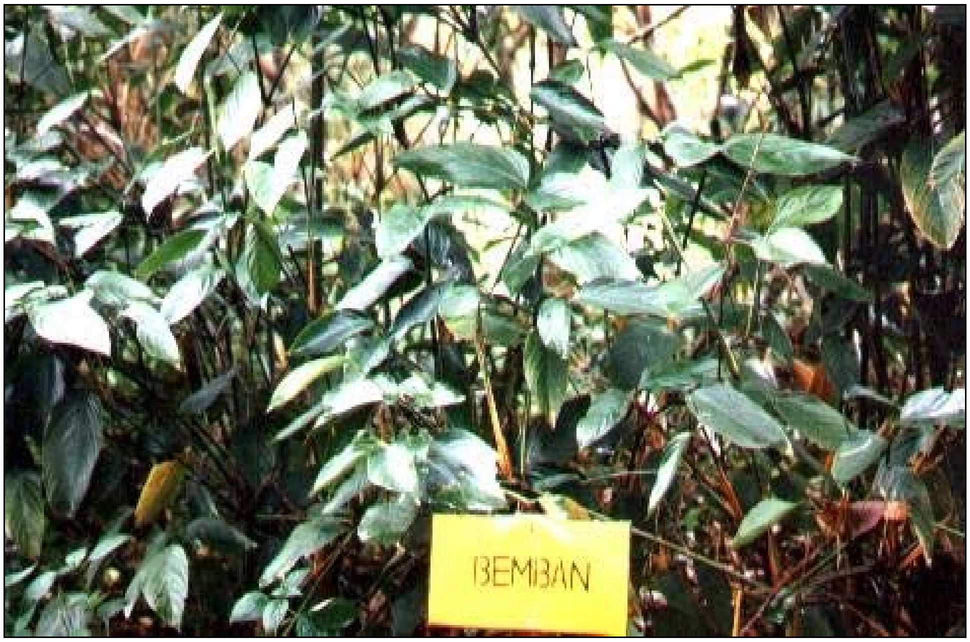


Figure 1.1: The bemban reed plant

1.2 Scope and objectives

It is reported that there were many researches have been done on natural fibre composites such as kenaf, flax, jute, coir, and hemp. However, bemban fibres do not have been used before commercially as a composite materials and thus, this study is aim to evaluate the potential of the bemban fibres in the future. To evaluate the potential of this natural fibre composites, the research concentrates on the basic properties of this fibre composite is carried out. Basically the objectives of this research are to determine the mechanical properties of unretted bemban fibres and the mechanical properties of bemban fibre composite.

In order to determine the objectives of this research, tensile test would be done on the specimen and the data from the test will be used to evaluate the mechanical properties of unretted long fibres composites.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural fibres

Before synthetic fibre reinforced composites are utilized, human being liked centuries ago, used natural composites in some applications. The Professional Way in ancient Babylon, one of the lesser wonders of the ancient world, was made of bitumen reinforced with plaited straw. Straw and horsehairs have been used to reinforce mud bricks (improving their fracture toughness) for at least 5000 years. A study done by Centre of Lightweight Structure TUD-TNO (2003) claimed that natural fibres as a substitute for glass fibres in composite components, have gained renewed interest the last decade, especially in automotive industries.

According to Mohanty *et al.* (2003), in automotive parts, compared to glass composites, the composites made from natural fibres reduce the mass of the component and can lower the energy needed for production by 80 %. Natural fibres possess excellent sound absorbing efficiency and are more shatter resistant and have better energy management characteristics than glass fibre reinforced composites. The application of natural fibres is motivated by a combination of environmental friendliness and economical feasibility, natural occurrences, renews ability of fibre resources, and biodegradability.

2.2 Properties of natural fibres

Natural fibres, including flax, are increasingly being used as reinforcement of polymer matrix composites (Joffe *et al*., 2002). Brouwer (2003) in his study entitled "*natural fibre composites in structural: alternative applications for sisal*" claimed in 1999, natural fibres used in the automotive industries comprised 75 percent flax, 10 percent jute, 8 percent hemp, 5 percent kenaf and 21/2 percent sisal. Eberle and Franze (1998) estimate that the coefficient for reduction in fuel consumption on gasoline powered vehicles ranges from 0.34 to 0.48 l/(100 kg×100 km) in the New European Driving Cycle, while the saving on diesel vehicles ranges from 0.29 to 0.33 l/(100 kg×100 km). In other words, over the lifetime travel of 175,000 km an automobile, a kilogram of weight reduction can result in fuel savings of 5.95–8.4 l of gasoline or 5.1–5.8 l of diesel, and corresponding avoided emissions from production and burning of these fuels.

A survey has been done by Karus, M. and Kaup, M. (2002) on the most important German and Austrian producers of natural fibre composites for the automotive industry. Basically, the survey results amongst the tier-one suppliers show that in spite of the relatively poor economic situation in the automotive sector in 2001 and 2002, the use of natural fibres (exclude of wood and cotton) for composites has further increased. Figure 2.1

shows the current development till 2002. According to this delineation, 15,100 tons were used in 2001, and a use of 17,200 tons of natural fibres for composites is forecasted for 2002.

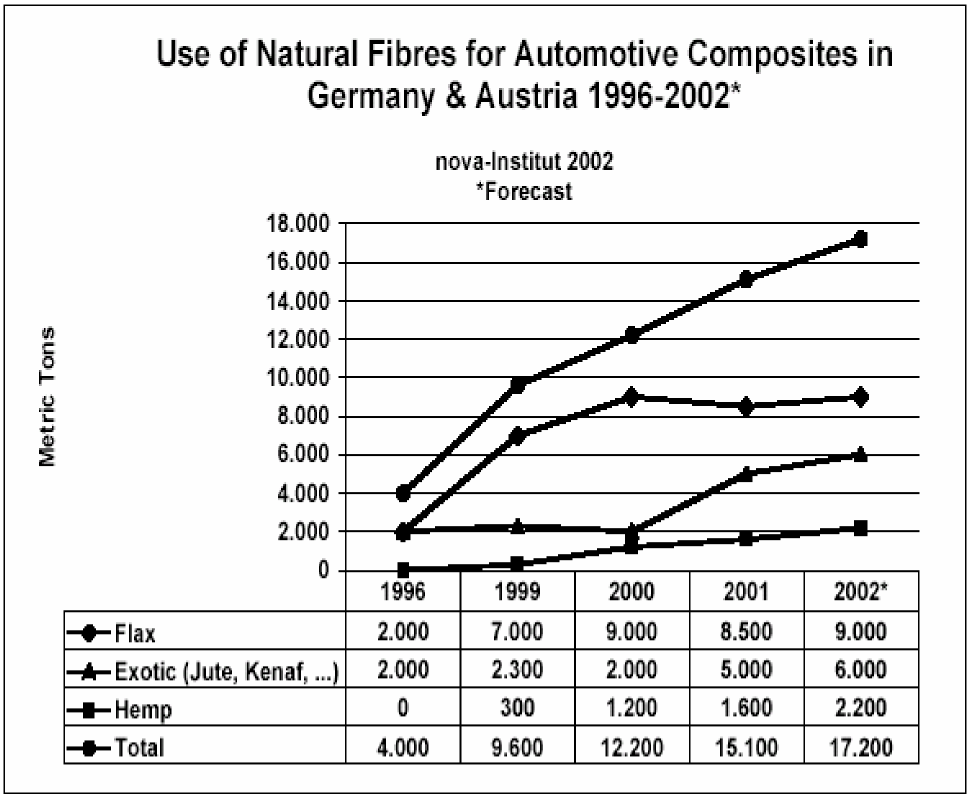


Figure 2.1: Use of natural fibres for automotive composites

(Karus, M. and Kaup, M, 2002)

Bhattaeharyya *et al*. (1961) have studied the effect of process variables such as curing temperature and time on the mechanical properties of jute fibres in phenol formaldehyde.

Dweib *et al*. (2003), have explored mechanical strength of different natural composite materials made of soybean based resin and natural fibres. It was reported that the flexural modulus increased from 1 GPa for the neat resin to about 6 GPa when the same resin was reinforced with recycled paper made from old cardboard boxes.

Kenaf, hemp and many other natural plant fibres have also been used widely in the European automotive industry. However, being hydrophilic, natural fibre need to be treated first to make them more compatible with hydrophobic thermosets and thermoplastics. Several researchers have reported improvement in mechanical properties of cellulose fibres when alkalized at different NaOH concentration. Bisanda and Ansell (1992) applied a concentration of 0.5 NaOH on sisal fibre while Sreekala and co-workers (1997), and Geethamma and co-workers (1995) used 5% NaOH to remove surface impurities on oil palm fibres and short coir fibres, respectively. Mwaikambo and Ansell (2002) treated hemp, jute, sisal and kapok fibres with various concentration of NaOH and found 6% to be the optimized concentration in terms of cleaning the fibre bundle surfaces yet retaining a high index of crystallinity.

The bulk (apparent) density includes all the solid materials and the pores within the fibres. The bulk density is always less than the absolute density, which excludes all the pores and lumen due to the buoyancy effect caused by the trapped air. Lower bulk density indicates higher porosity as pores have been found to reduce the density of materials. The absolute density of most plant fibre is between 1400 and 1500 kg/m^3 (Mwaikambo and Ansell, 2001).

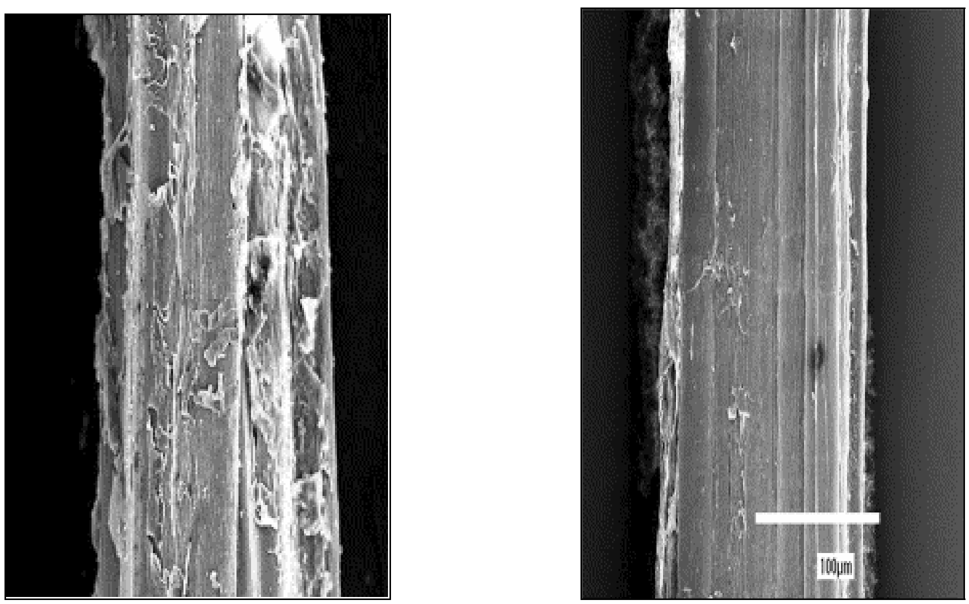
Table 2.1: The effect of alkalization (6% NaOH) on fibre bulk density.

(Sharifah and Ansell, 2003)

Types of fibre bundles	Treatment (alkalization)	Bulk density ρ_b (kg/m^3)	Change in bulk density (%)
Hemp	Untreated	1449.0	0
	Treated	1465.9	+1.2
Kenaf	Untreated	1192.6	0
	Treated	1221.7	+2.4

From Table 2.1, both fibres do not show a significant change in bulk density after alkalization. However, a positive change in fibre densities was observed for both treated kenaf and hemp fibres. A positive change in fibre densities normally signifies cell wall densification. A negative change would signify cell wall damage leading to de-polymerization of the cellulose molecule. Mwaikambo (2002) reported a negative change in bulk density of sisal fibre bundles at 6% concentration of NaOH implying that caustic soda may have degraded the primary wall by removing soluble components such as hemicelluloses. He also reported that higher concentrations of NaOH are likely to damage the cell wall and reduce the bulk density.

Examinations were carried out on the untreated and alkalized fibres to study the morphological changes that occurred after treatment of the fibres. The scanning electron microscopy (SEM) micrograph of the longitudinal surface of untreated fibre bundles in Figure 2.2(a) shows the presence of wax, oil and surface impurities. Waxes and oils provide a protective layer to the surface of the fibres. The longitudinal views of 6% NaOH treated hemp fibre in Figure 2.2(b) show a very clean surface. The surface of the treated fibre appears to be quite smooth but in fact is roughened by the chemical treatment.



(a) (b)

Figure 2.2: SEM micrographs of longitudinal views of (a) untreated hemp fibre and (b) 6% NaOH treated hemp fibre (Sharifah and Ansell, 2003)